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GUIDELINES IN ACCUMULATING FINANCIAL DATA ON FUTURE WEAPONS

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SUMMARY

Weapon system evaluation involves systematic and critical examination of alternative means of performing specified military tasks or missions. In this analytical process it is necessary not only to measure technical and operational capability, but also to obtain a reasonable estimate of total financial requirements and the variations from case to case. This paper attempts to provide guidance in collecting the financial data necessary to the evaluation.

The brief background discussion in Section I deals with cost concepts, the handling of uncertainty, and the necessity of insuring that financial information will prove appropriate to the end use for which it is intended. Section II shows the overwhelming importance of descriptive data in examining each of the alternative hardware designs, operational concepts, or test and development schedules. Section III furnishes two basic forms which lay out the major cost elements that need to be estimated in order to predict the economic impact of the future weapon system.

Form 1 lists functions which a commercial contractor or government arsenal might perform when developing and producing the weapon. Form 2 presents a generalized list of cost elements covering the total resource requirements for development and test, for procurement in quantity, and for the operation of the system over a period of years.

CONTENTS

I. BACKGROUND

A. THE PLACE OF COST IN THE OVER-ALL EVALUATION PROCESS

Weapon system evaluation involves systematic and critical examination of alternative means of performing specified tasks or missions. In this process alternatives of several types are usually considered. Various weapons or mixes of weapons are analyzed and within a weapon class alternative hardware designs are studied. Numerous modes of operation on the more promising of weapon system designs are reviewed and test of these operational concepts in several time periods ascertains how effective they are against probable enemy threats during each period. In such evaluations it is necessary to measure in terms of military capability the value of each of these alternatives, and also to seek a reasonable estimate of the total financial requirement and how this varies from case to case.

In past years the kinds of information on effectiveness and cost needed for systems evaluation seldom were available. When available, data was seldom found to be comparable. More recently, emphasis has been placed on developing parametric data on the technical capabilities that alternative proposals may exhibit. However, less attention has been given to the important over-all financial implications of the same series of possible systems. Future weapons now under consideration are so complex, and projected budget limitations are so severe, that we must give more thorough study to financial aspects of the evaluation process.[1]/

Systematic review of the major human and material resources required in each phase of the development, procurement, and operation of a potential weapon system is necessary to arrive at realistic estimates of total cost. Since this involves careful consideration of each successive step in

development and phase-in, the process offers an additional benefit--it assists in attempts to minimize leadtime. This is often an overpoweringly important factor.

Since financial information plays a very important role in determining appropriate allocations of resources, the data to be accumulated must be relevant and consistent. The persons most capable of preparing these data are those with financial experience and thorough familiarity with the proposed systems. Because cost estimates for alternative systems are likely to come from several different groups of people, it is important to insure that these estimates are consistent in format and content. Otherwise, comparisons will not be meaningful.

In the present research memorandum appear three general types of guidelines for the accumulation of useful financial information. This introductory section discusses cost concepts and objectives. In the second portion is descriptive information necessary to evaluate financial data. This covers the major phases of the proposed development and operational schedule, the larger components of prime or mission hardware, the basic features of the operational concept, and technological or resource shortage problems.

The third section of this paper provides basic check lists of cost elements to be considered when accumulating consistent and comprehensive estimates of total resource requirements. These check lists are divided into two main parts: development, production, and support items as well as the industrial facilities required by the contractors or arsenals producing the equipment; and the cradle-to-grave costs for research and development, the initial investment to place the system in the field, and

costs of operation for number of years. Brief instructions and definitions of line items are provided.

Because the systems involved are likely to become available in the fairly distant future, the greatest emphasis is placed on comprehensiveness and comparability with somewhat less importance being attached to accuracy. Since sizeable numbers of alternative cases are apt to be involved, a minimum of computation and detail is desirable. The formats in Section III are concise and suggest summarization in categories meaningful for analysis.

B. THE FINANCIAL DATA CYCLE

In the military weapon system evaluation process, where the number of intellectual disciplines and organizations involved are great, definition of categories and the usefulness of various types of financial data are often uncertain. Financial information is prepared for many different purposes. Usually the first time that costs are considered in a given weapon system program is when early feasibility evaluations are made. This paper is primarily addressed to that purpose. As indicated in Chart 1, cost data also is required - often in increasing detail - as the program proceeds through the development and operational sequence. For the total planned force structure, the first demand for financial justification is from the budget mechanism.[15,23] Later, cost data is required both in awarding contracts and in efforts to insure delivery at reasonable cost. Formal financial information (often highly aggregated) is also required to control expenditure levels and to insure legal and prudent disbursement of public funds.[12] Finally, permanent records of actual costs incurred should be maintained in sufficient detail so that data will be available as

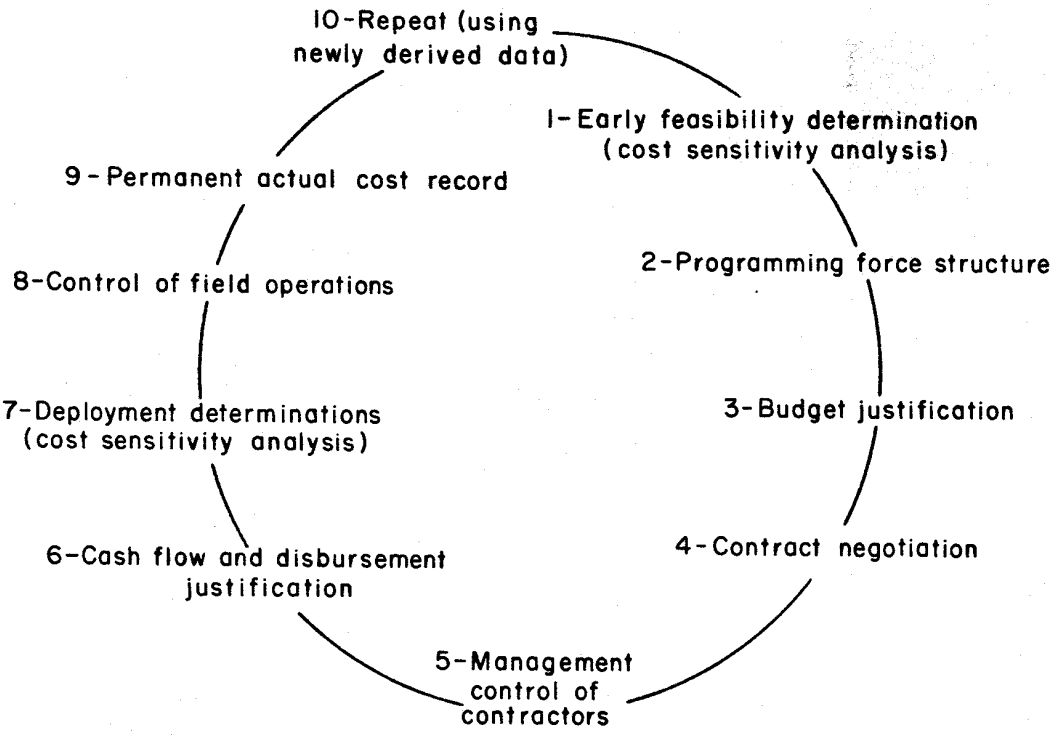


Chart I — The financial data cycle

historical background for usefulness when preparing estimates for the next series of systems. Competent cost estimating depends heavily on this regenerative cycle of data inputs.

In each of these financial phases somewhat different types of considerations and levels of detail are relevant. An individual's views of what is required in the way of cost data often reflect only his familiarity with operations at a particular step in the cycle. In addition, cost work may be initiated within each operational function with insufficient knowledge of related information existing in other portions of the preparing agency. Accumulation of data for each of the purposes shown in this cycle means more and is simplified if there is understanding of the needs of

preceding and subsequent users of the information. Smooth transition from phase to phase in development, procurement, and operation is eased if cost reporting requirements are carefully integrated. The pieces of the over-all data accumulation system--and it should be viewed as a single system--can best be tailored to the functions being served in each separate phase when the total needs of all steps in the financial sequence are understood. Determination of appropriate content and level of detail is then facilitated and the flexibility necessary to interpret rapidly various changes in the weapon program is provided.

C. COST CONCEPTS

In order to prepare any cost estimate, it is necessary to construct a framework of basic assumptions on method. The following discussion is intended to suggest concepts that are integral to such a framework.[10,18]

Chart 2 — Cost concepts

- Total activity cost
- Consistency in method
- R and D vs investment vs annual cost
- Proration of support costs
- Incremental cost
- Time-phasing

1. Total Activity Cost

The goal in gathering financial data for early feasibility evaluation purposes is to determine the total additional cost to the nation that would be incurred if the proposed system should be developed, procured, and operated over a period of years. This requires outlining the development program and projecting the system in an operational context in a specified unit of tactical capability, for example, a squadron or battalion. The costs to be estimated need to be comprehensive. They must include not only the prime operational hardware items, but also research and development, installations, personnel, support equipment, and supplies, etc. required to make the system fully operable over a designated number of years.

2. Consistency in Method

Since the evaluation of future system proposals requires the comparison of whatever alternative systems are available to perform a given task or mission, great care must be exercised to use cost estimating methods which avoid biases that either favor or discriminate against some of the possible alternatives. Particularly for systems which are in the distant future, consistency in estimating method is more important than an attempt at a high degree of arithmetic accuracy. It is especially significant when (as is often the case) several different contractors or other organizations are involved in the development and construction of a single weapon.

3. R&D vs. Investment vs. Annual Cost

The "one-time" outlays for developing and introducing the system into the operational inventory should be segregated from the recurring or annual operating cost to be incurred after the system has been phased into the force. This distinction is important from the standpoint of identifying

costs that occur repeatedly. The two types of expenditures also differ considerably in their time of impact.

It is important to differentiate between outlays required to develop a workable system, and the expenditures necessary to procure and install an operational force of a given size. For systems currently in full-scale development, the logical segregation is found in the assignment of hardware and associated items procured for operational inventory. Hardware procured for test purposes should be included as an R&D expense. For a system in the more distant future, assumptions should be made concerning the level of performance which must be achieved before purchasing the weapon for operational use. Then the probable magnitude of the test program required to achieve that level of performance should be estimated. In selecting this level one should take into consideration the fact that international, budgetary and other pressures in the real world often force the acceptance of a lower level of performance than is desirable in order to obtain an earlier operational capability. Whatever assumptions are used on this account in preparing the estimates should be specified.

Since comparison of alternative systems may be sensitive to the number of years the weapons are to be employed, it is desirable to develop operating costs on the basis of several assumptions about the length of time the system will be operable. For example, three, five, and seven years for each unit of the force to be deployed usually are appropriate. Time consumed by phase-in and phase-out would make the period of operation at peak force-level considerably less than this in each case.

4. Proration of Support Costs

Analysis of the effectiveness and cost of military missions implies orientation on a weapon system basis as well as the assignment of all major costs of the total military activity to the appropriate weapons. When total force structures are being analyzed, it is possible (although not always logical) to prorate expense up to and including the cost of operating the Pentagon. In many situations, however, information on future total force structures is not available. Then it will be difficult to envision what portions of support activities are directly related to a particular weapon. Since record-searching and computation should be kept to a minimum in order that pricing of a large number of alternative cases may be feasible, certain approximation devices must be used.

Conventional Support. Frequently repeated demand for estimating tools has led experienced personnel to develop cost factors which can be used to prorate many of the more conventional elements of support required during the operational phase, such as installation and vehicle maintenance, personnel service functions, issuance of standard supplies, etc. For convenience, it is suggested that the estimator preparing data on alternate concepts for a single weapon system apply such factors but limit his efforts to support up through the depot-level. In other words, he should not attempt to allocate the costs of support provided by major command headquarters and above.

New Support Systems, Development Support, and Interagency Sharing. In many cases development costs or other major investments in equipment and facilities are shared by several primary weapons. Current examples are elaborate electronic command and control systems, major propulsion boosters,

test launch equipment, and data acquisition and analysis equipment. In such cases the suggested procedure is to include an estimate of the total cost of such support items as footnote material and then clearly indicate what portion of this has been assigned to the weapon along with a brief statement of the reasoning behind the assignment.

When estimating the cost of a potential system which is apt to be under the primary jurisdiction of a particular military service (and usually it is important to segregate cost by service), total cost should be shown and breakout by service should be approximated as closely as possible according to the current assignment of missions. The allocation of development and test costs is often difficult; therefore, the assumptions used should be stated explicitly. This same procedure is appropriate when agencies not in the Department of Defense--such as the National Aeronautics and Space Administration or the Atomic Energy Commission--are involved. For example, in costing a strategic missile which will be operated by the Air Force and uses nuclear propulsion, assume that development of the reactors and fuel for operation will be provided by the AEC but that the Air Force will pay all other costs, including production of the reactor after it has been developed.

5. Incremental Cost

During the next several years, it is anticipated that a substantial defense force will be in existence at the time of phase-in of new weapons. In planning future systems, the significant costs are those which are incremental, that is, which represent the net resource drain that would be imposed upon the nation if the proposed system were to be purchased. Assets which can be made available from previous weapons should not be charged to

a new system. The most orderly method of handling this is to prepare the over-all total cost, assuming no inheritance, and then deduct all items which probably can be carried over from previous systems. Inclusion of both the total and the net figures allows maximum flexibility for adjustment of the estimate with changes in weapon development, design, or operational concept. Possibilities for inheritance should be examined under each cost element, especially in the R&D and investment categories. Often considerable amounts of available test equipment, operational support equipment, facilities, trained personnel, and stocks of supplies can be used by the new weapons. Obviously, it is very difficult to estimate what the available inventory situation will be at the time of phase-in of a new system in the distant future. This is an additional reason for showing the grand total cost, assuming entirely new procurement, and then explicitly listing all assumptions made regarding subtraction of inheritable items.

6. Time-Phasing

From the budgetary standpoint, it is important to understand the time-phasing of the cost implied by future system proposals, i.e., the financial requirement imposed each federal fiscal year (1 July - 30 June) by the schedule or schedules furnished. To insure consistency of time-phased data and to establish a standard conceptual framework of data accumulation, the following rather substantial list of assumptions is suggested. This is not meant to imply that time-phasing should be examined in great detail for preliminary feasibility proposals. It is provided to establish a standard basis for analysis.

Importance of Scheduling. (1) Furnish a schedule which lays out as a minimum the main phases of the development program, the size and timing of the test effort, and the time of phase-in and phase-out of each operational

unit. (2) Show data in terms of required obligational authority as opposed to expenditures or commitments. (3) In determining the obligational authority data, assume the new incremental funding concept as opposed to conventional funding. Conventional funding requires appropriation of the total cost of specific units of hardware or facilities regardless of the time when disbursement of the funds would take place. Obligational authority under incremental funding covers expenditures required during the fiscal year with adjustments only for accounting lead times (plus certain allowances for minimal advance commitments on materials).* (4) If a rough allocation by type of appropriation or fund is required, approximation to the major program level only is suggested.6/ For example:

Program Number	Title	Approximate Lead Times Assuming Incremental Funding
600	Research, Development, Test and Evaluation	1 year
100 200 800	Major Procurement** - Aircraft -Missiles -Electronics, Other Equipment	1-1-1/2 years
300	Construction of Operational Facilities	2-3 years
400 500	Maintenance and Operation (including pay of military personnel - 500)	6 months

Approximate lead times by type of fund, assuming the incremental funding concept, are shown above at the right opposite the major fund designations.***

*Under the incremental funding concept, specific hardware items often are funded from appropriations of two or more years. For simplicity of explanation, it is suggested that the hardware to be paid for out of a single year of funding be expressed in terms of the equivalent number of units to be produced with the funds available for the year.

**Including test inventory, support equipment, and industrial facilities.

***It should be noted that although the trend is in the direction of incremental funding, as of May, 1960, only a relatively small number of major procurement programs are as yet operating under the concept.

(5) Assume that replacements and spares will be procured and paid for as required, allowing normal inventory pipeline time.*

The Learning Curve. Equipment costs per unit, and therefore programmed costs, are to reflect the fact that cost declines as the quantity produced increases. A cumulative average learning curve can be used in preparing the basic cradle-to-grave cost estimates to be used in the forms in Section III. In approximating the time-phased implications of this procurement, however, costs should be read from the corresponding unit learning curve by annual equivalent production lot at approximately the mid-point of the lot.5/

Inflationary (and Deflationary) Trends - Constant Current-Value Dollars. Constant dollars assuming the current year as a base should be used throughout the time-phasing exercise. As a matter of general interest one may wish to include in addition the impact per fiscal year assuming constant inflationary levels of, for example, two, three, or five per cent. Such economic computations should be supplemental to the basic cost analysis.

Refinements in Technique Not Recommended. Other techniques which are not recommended for use either because they are not as yet perfected for use in military investment decision problems or because they are too involved for use in predicting the financial impact of highly futuristic systems include the following: (1) attempts to take the cost of money into consideration by discounting to present value as is done in many investment decisions in the private sector of the economy; (2) inclusion of an allowance for depreciation of government assets in estimating inheritable items;

*In other words do not assume a close out run to produce a long-term supply of replacements and spares immediately following production of items programmed for operational phase-in of the weapon.

or (3) assumption of a formal functional relationship between total cost and the speed of development and procurement, that is, the time-cost curve. (4) Comments on the appropriateness of including measures of probability are presented in Section D.

D. THE UNCERTAINTY ISSUE

It is recognized that great uncertainties are involved in evaluating future international political and economic conditions, rate of progress of technical state-of-the-art developments, and a host of other factors bearing directly or indirectly on weapon system requirements, capabilities, and producibility. Extreme care must be used in determining weapon design, operational concept, or appropriate phasing of the development, procurement and operational program.

Unfortunately, it is not possible to deal with these uncertainties using traditional statistical or probability techniques. Calculation of confidence limits and standard errors of estimate, for example, requires the drawing of a sample from a defined population. In the case of future weapon systems, one has no sizeable sample to examine and from which to determine the usual statistical measures.[9,22]

In the absence of the applicability of such tools, a less formal technique--frequently called cost sensitivity analysis--currently is proving useful in dealing with the financial side of this problem of uncertainty.[1,3] Since our objective is systematic and critical examination of alternate designs, deployments, and schedules, this tool consists of an organized procedure for pricing the series of alternative cases being studied. The results thus derived provide estimates of the financial sensitivity to changes in value of a particular technical or operational parameter. This

permits a bracketing of the range within which the economic impact of variations in the uncertain parameter may fall. It is convenient to consider presentation of the impact of the differing resource requirements for these alternative designs, deployments, development programs and schedules as ranges of values.

In many cases, there is also uncertainty on the cost estimate itself--even assuming a well-defined design. This uncertainty, though significant, is often of considerably less magnitude and usually is confined to a relatively small number of cost elements. For example, since manufacturing techniques have not yet been perfected for the fabrication of large stainless steel honeycomb sheets, it is indefinite what the cost of this process will be. On the other hand, many of the other elements of the over-all cost of producing and operating a supersonic bomber, for instance, are far more conventional in nature. They can therefore be estimated with greater certainty. To differentiate, presentation of alternative figures to handle this cost estimating uncertainty can be referred to as a range of estimates. Chart 3 illustrates these two types of uncertainty.

Chart 4 illustrates the planning process in which great numbers of alternatives are fed into the analysis of the various methods for performing a given mission in the distant future. As analysis progresses (and time passes) the breadth of range of alternatives as well as the range of their consequent financial impact becomes less broad until finally the one, two, or three best methods or weapon systems are forced to emerge. Likewise as experience on the type of system increases greater certainty is gained about the cost estimate itself. Both the range of values and the range of estimates narrows over time. Throughout this process, real

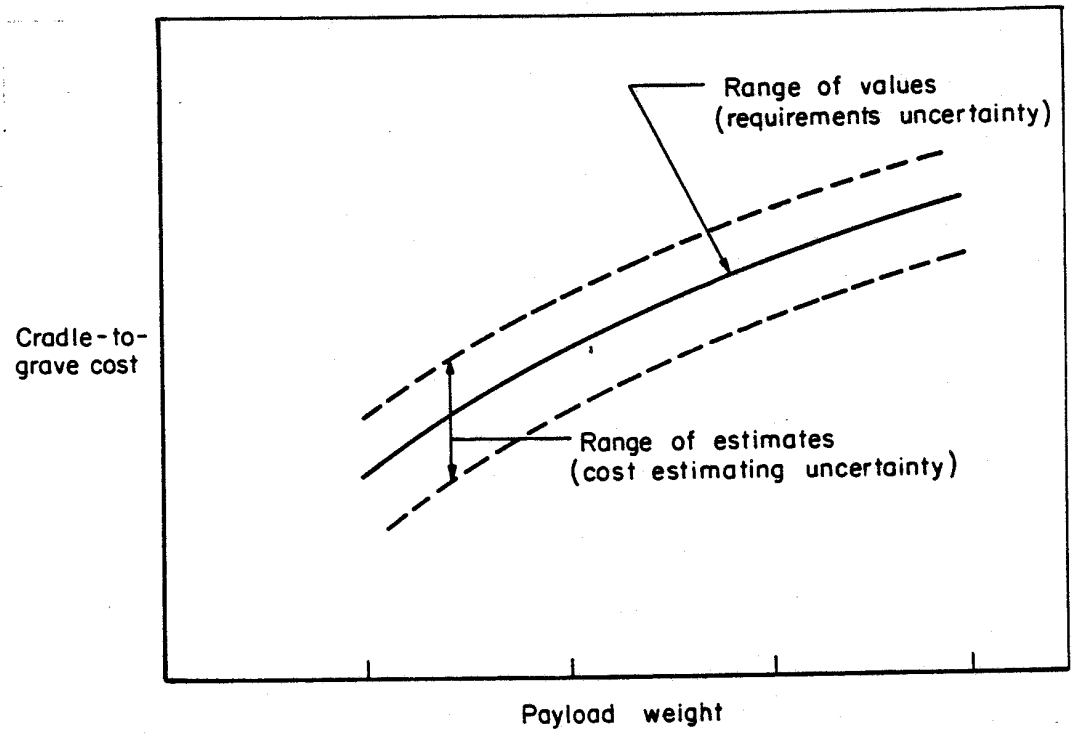


Chart 3 — Types of uncertainty and ranges for a given parameter

All other assumptions concerning weapon system design, development, and deployment remain constant

world constraints--for example, the necessity of developing budget inputs--are mitigating toward selection of an "expected" or "most likely" value from these ranges. This "quest for certainty" and the resulting determination of a "certainty equivalent" is presented more confidently if a careful analysis of alternatives has been undertaken than if dollar requirements have been selected intuitively.7/

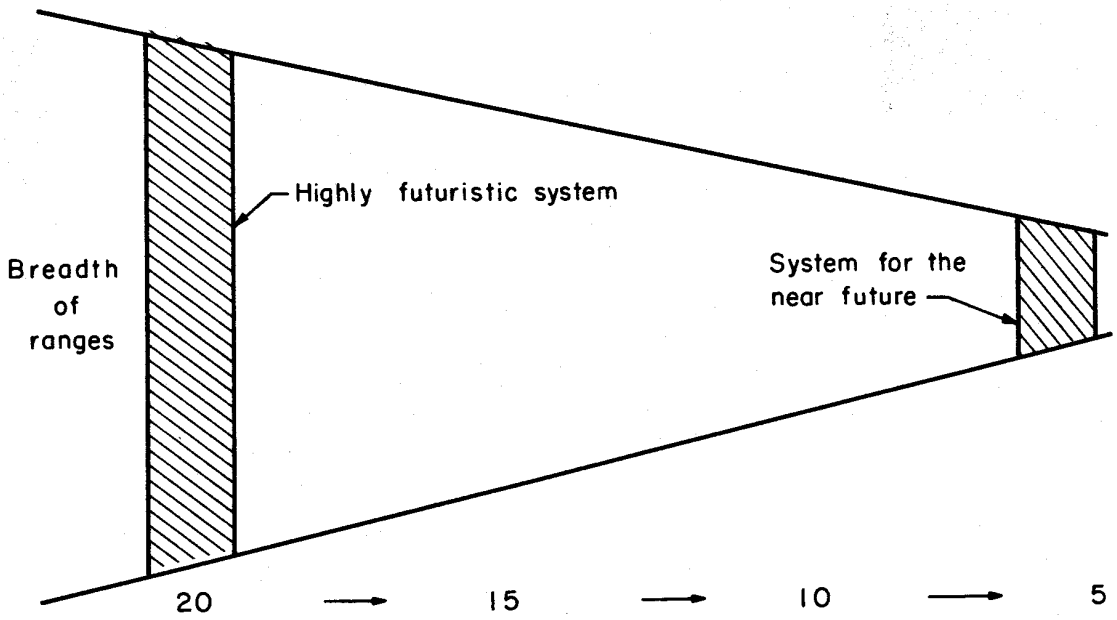


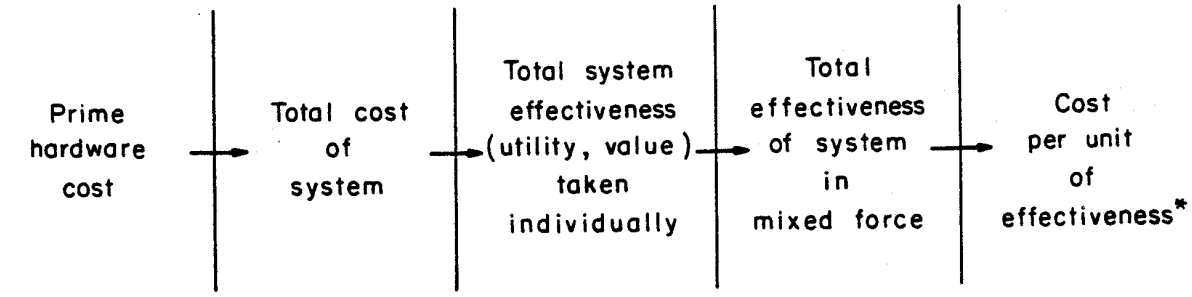
Chart 4 — Cost sensitivity analysis

Ranges of values and estimates approach to uncertainty

Whether one expresses himself in this operations-research-type terminology or states the problem as simply one of bringing all of the facts to bear to decide which weapon to build, the necessity for accumulating pertinent financial inputs for dealing with the uncertainties involved is equally pressing. Uncertainty implies change and a change in either a requirement or an estimate can result in revision of the financial support necessary for a program and more importantly, in the relationship

of the value to be received (effectiveness) to the cost to be incurred (Chart 5). Data accumulation in support of planning activities should attempt to collect information which is sufficiently flexible so that the financial impact of the change can be estimated expeditiously. More hopefully, the revised situation may already have been studied as one of the alternatives in the original weapon system evaluation.[11,14]

Chart 5 — Effect of change on findings of weapon system evaluation



*Calculated from the cost required to obtain a desired level of effectiveness—i.e., the denominator of the ratio should be fixed in order for the comparison to be meaningful.

II. DESCRIPTION

As mentioned above, the most severe problems in estimating and hence, the greatest potential for inaccuracy in assessing economic resource impact is the difficulty in predicting the form which a weapon system or its operational concept will take. And financial data not properly referenced to the system for which it was prepared is of little value. In general, what is required is a framework of the system described as specifically as possible with particular attention paid to any factors about which there is question with regard to sensitivity in terms of system cost. In view of the breadth of the national security mission (Chart 6), it is extremely difficult to generalize a list of descriptive elements which adequately will cover all potential types of weapons.

CHART 6—BREADTH OF NATIONAL SECURITY MISSION*

- R & D
  - BASIC
  - COMPONENT (INCL. NUCLEAR)
  - PRESTIGE MISSIONS AND EXPLORATORY DEVELOPMENTS
  - WEAPON SYSTEMS
- OFFENSE
  - UNLIMITED (STRATEGIC (ESP. NUCLEAR))
    - MISSILES
    - AIRCRAFT
    - SPACE MISSIONS
    - SEABORNE
  - LIMITED (TACTICAL)
    - LAND, SEA, AND AIR
- DEFENSE
  - PASSIVE
    - RECONNAISSANCE
      - AIRCRAFT
      - SATELLITE
    - IDENTIFICATION AND TRACKING
    - CIVIL DEFENSE
  - ACTIVE
    - AREA
    - LOCAL
- COMMON/SUPPORT
  - COMMAND AND CONTROL
  - MAINTENANCE, SUPPLY, AND TRANSPORTATION
  - TRAINING

* NOT TO MENTION THE EVEN BROADER AND MORE SUBTLE AREAS SUCH AS ECONOMIC WARFARE, MILITARY SUPPORT TO UNDERDEVELOPED COUNTRIES, AND DISARMAMENT OR ARMS CONTROL.

For this reason the check lists included in this section must be considered to be illustrative rather than definitive. They should at least suggest the major variables to be described. However, to facilitate analysis of the data, descriptive information should be provided in the order and format shown whenever they can be deemed to be appropriate. In this section, three major check lists are furnished covering characteristics of (1) the prime weapon hardware; (2) the development and operational concept; and (3) the phasing of the development, procurement, and operational program. A brief fourth list of potential bottlenecks is included to enable the recipients of the data to review major possible problem areas in an orderly fashion.

A. PRIME HARDWARE

This first characteristics list (Table 1) on mission hardware applies primarily to missile and space weapons. Breakouts of major components are furnished for selected types of equipment only; for example, in the propulsion area, liquid and solid rockets are itemized. Weights of ramjets and nuclear turbojets and rockets also should be divided into their own appropriate subcomponents. Relatively minor modifications of this check list also are in order when describing aircraft systems. A brief check list on electronic defense or command and control systems is included in Table 2. It is suggested that one should select and furnish the appropriate key descriptive data, adding any other information necessary to an understanding of the cost material.

Table I — Prime hardware description*

CHARACTERISTICS:

Performance	Physical	Other
Type of Vehicle - Strategic, Defense, or Tactical Launch/Impact Points Trajectory Staging Arrangement Maximum Range Speed Flight Time Altitude	Weight-Dry (by component & Stage) -Wet (take-off weight with propellant) Size Airframe Material Type of Propulsion Propellant Recoverable or Nonrecoverable Type of Guidance Accuracy Description of Payload Components	Cognizant Agency WS, SR, or Project Number Manufacturer(s)

WEIGHT DATA ON MAJOR COMPONENTS:

Airframe (By Stage)	Propulsion (By Chamber Within Stage)		Guidance		Payload	
	Liquid Rocket	Solid Rocket	Inertial	Radio (Airborne Element Only)	Missile System	Space System
Structural Leading Edges Skin (Incl. Tankage) Structural Members (Frame) Subsystems or Controls -Electronic -Mechanical System Integration or Assembly	Pump Drive Assembly Turbo-Pump Gas Generator Thrust Chamber Propellant Lines & Fittings Vernier & Exhaust System Frame or Mounting Structure Accessory Power Supply	Casing Nozzle Propellant	Measurement Unit Platform Accelerometers Gyroscopes Computer Control & Assoc. Elect.	Decoder Beacons Antenna	Nose Cone Shell Arming & Fusing Warhead	Unmanned Structure Shell (incl. frame, skin & stabilization) Shielding Nonpropulsive Power Guidance Communications (Radio, Video, etc.) Mission Component Sensor (Reconnaissance, Meteorological, Exploratory, Communications, etc.) Destructive Payload Other Specialized Packages (incl. Biological) Recovery Mechanism (Rocket, Beacon, etc.) Manned Add: Crew Compartment (Life Support Elements) Escape Vehicle Compartment

*Primarily missile and space system oriented. Minor adjustment is necessary for aircraft. Part VI of Table 2 provides a list of characteristics for ground electronic defense networks.

B. DEVELOPMENT AND OPERATIONAL CONCEPT

Table 2 attempts to organize the considerations of interest to the financial analyst in studying the economic implications of a concept for development and operation of a proposed weapon system. These are divided into information concerning the development program, size of the force, mission, type of basing, and methods of support. Again the list is illustrative rather than definitive. In the final section of the table (Part VI), the problem of describing the layout of ground electronic systems is treated in some additional detail.

Table 2 — Development and operational concept description

CHARACTERISTICS:

I. Development & Test Program

No. of Live Tests.
Number, general type, and duration of Static Tests.
Extent of State-of-Art Advance: Off-the-Shelf, Slight Advance, or Extensive Advance.
Prime emphasis on Component, Static, or Live Test.
Reliability required prior to turn over for operational use.

II. Force and Organizational Unit Size

Total Size of Force (no. of unit equipment (UE) items).
No. of Prime Hardware Items per Organizational Unit i.e., squadron, battalion, etc. (incl. complementary systems, for example: air-to-surface missiles (ASM) on aircraft).
No. of Squadrons (Battalions, etc.) per Group, Groups per Wing, etc.

III. Mission

Rate of Fire (Salvo Capability) - Initial volley per UE unit.
Response Time - elapsed time between order to fire and actual launch.
Single vs. Multiple-Target Capability - no. of destructive payloads per UE item.

Reliability of Prime Hardware (example: orbit duration, mean-time-to-failure, shelf life, etc.)
Coverage - Per cent of total potential target or reconnaissance area being covered at any point in time.

No. of Flights per Year.
Average Length of Flight.
Per Cent of Force Airborne.

Prepared Self-sufficiency Time - Amount of time UE unit can support itself independently.

IV. Basing (Earthbound)

Location - Country
- Latitude
- Type of terrain (Example: mountain, prairie, desert, or lush tropical).

Fixed vs. Mobile Operation:

Fixed	Mobile
Permanent vs. Temporary Installation	Truck, Train, Sea (river, lake, or oceanic) or Air.
Independent Base vs. Tenanted	No. of Vehicles in Caravan, Train, or Fleet.
Soft (above ground) vs. Hardened	Existence and Extent of Prepared Stop-Over Points.
Degree of hardening - (Minimal up to 10-20 psi; 100 psi; or superhard concrete or mountain cave).	Set up Time.

Dispersal - No. of dispersal points per squadron.
- Distance between points.
- Distance between squadrons.
- Extent to which share common control centers or support areas.

V. Support Programs

Layout of Communications or Command & Control System.

Manning Concept or Crew Duty Period (example: eight hour shift; two-week i.e., firehouse; or number of months in orbit).
Personnel Mix (example: military (officers vs. airmen), government civilian, or contractors.

Training Concept - Location of initial individual and weapon system training, training of replacements and proficiency training; no. of live operations; extent of use of simulation devices; length of courses, etc.

Maintenance Concept - location of performance of organizational, field, and depot-types of maintenance; military or contractor.

Transportation Concept - method of delivery of initial and continuing support materiel and manpower requirements to operational location; average distance.

Table 2 — (cont.)

VI. Ground Electronic Networks

In many cases, ground electronic gear represents an important and integral part of the complete weapon system and in some circumstances such as major defense warning networks or command and control systems, these gear are in fact the prime equipment of the system. Suggested descriptive information for these networks is as follows:

Type of Mission - Example: threat determination (surveillance and reconnaissance); warning; tracking; guidance and fire control; data analysis and presentation; command and control.

Brief Functional Description of the System - (Incl. such items as centralized vs. dispersed data processing; degree of automation of major functions; real vs. non-real time requirements.

Layout of System - No. and types of stations; general classes of equipment at each type of station; approximate geographical locations; distances between stations, etc.

Characteristics of Basic Equipments:

(1) Data Acquisition Equipment -

Active		Passive
Radar, sonar, seismic, etc.		Type of Sensor - (Infrared, RF, visual, magnetic, etc.)*
Example: Radar	- Performance: Range, resolution, discrimination level, noise level.	
	- Physical: Power requirements, antenna size.	

(2) Data Processing Equipment -

Computer
- Performance: Capacity, data handling rate (or if possible, such more detailed characteristics as erasable memory capacity, program steps, word length, machine speed order structure, etc.

Other (Incl. Input-Output)
- Briefly outline other equipment requirements - photographic, telemetry recording equipment, conversion equipment (map-to-digital; analog-to-digital), etc.

-(NOTE: Also Indicate Approximate Programming Requirement.)

(3) Data Presentation and Management Control Equipment
- Brief description indicating nature and magnitude; manual vs. electronic; go - no-go or more elaborate, etc.

(4) Communications Equipment Incl. Landlines (Among each of the 3 above)
- No. miles; mode of transmission (wire, radio, or cable); capacity (no. of channels); speed of transmission, redundancy and allowable error rate; psi hardening.

*Airborne portion priced from Table 1 - Prime Equipment.

C. PROGRAM PHASING

Detailed scheduling by subsystem and the programming of major milestones for each of these components is an unnecessary refinement for early economic feasibility analysis.[2,8,19,20/] On the other hand, a general layout of the over-all program for development, procurement, and operation of this system is necessary in order to estimate the approximate timing of the financial impact. Such a layout is suggested in Table 3. A condensed table of this sort should be prepared for each schedule on which time-phased costs are furnished. In this schedule, the left end of the bar indicates initiation date and the right end completion date. Numbers of tests or numbers of units are shown during the period of occurrence or delivery with the area in the bar preceding these numbers indicating lead time. Bars on facilities show the construction period with the right end of the bar indicating the beneficial occupancy date (BOD). In preparing the table it may help to refer back to the discussion on time-phasing in Section I.

D. POTENTIAL BOTTLENECKS: STATE-OF-THE-ART AND RESOURCE SHORTAGES

In this section, list those potential problem areas which it is possible to identify at an early point in time. In the process, review factors such as those shown in Table 4, describe concisely the techniques to be investigated to resolve these problems and furnish an estimate of the magnitude of the effort involved.

Table 3 — Program phasing

PHASES	F.Y. Qtr.	Gov't or Contractor Responsibility
I. Feasibility Study & Preliminary Design		
II. Development (Incl. Testing)		
Engineering Design - Component		
Example:		
Airframe		
Propulsion		
Guidance & Control		
Payload		
Support Equipment		
(etc.)		
Engineering Design-System		
System Mockup & Prototype		
Engineering Tooling		
Testing		
Component Test		
(No. of Equivalent Units)		
System Static Test		
(No. of Equivalent Units)		
System Live Test		
(No. of Units)		
III. Production		
Production Engineering		
Production Tooling		
Operational Units (Mfg., Phase-In, Years of Operation, & Phase Out)		
Sqdn. or Btln. #1 (No. of Units)		
Sqdn. or Btln. #2		
Sqdn. or Btln. #3		
Sqdn. or Btln. #4		
Sqdn. or Btln. #5		
IV. Support		
Support Equipment - Manufacture		
- Installation, Activation, & Test		
Data Acquisition & Analysis-Test		
- Operational		
Training - Personnel		
- Simulation Equipment		
Logistics - Spares, etc.		
- Maintenance		
Facilities- Industrial		
- Test (No. of Launchers, etc.)		
- Operational (No. of Sqdns.)		

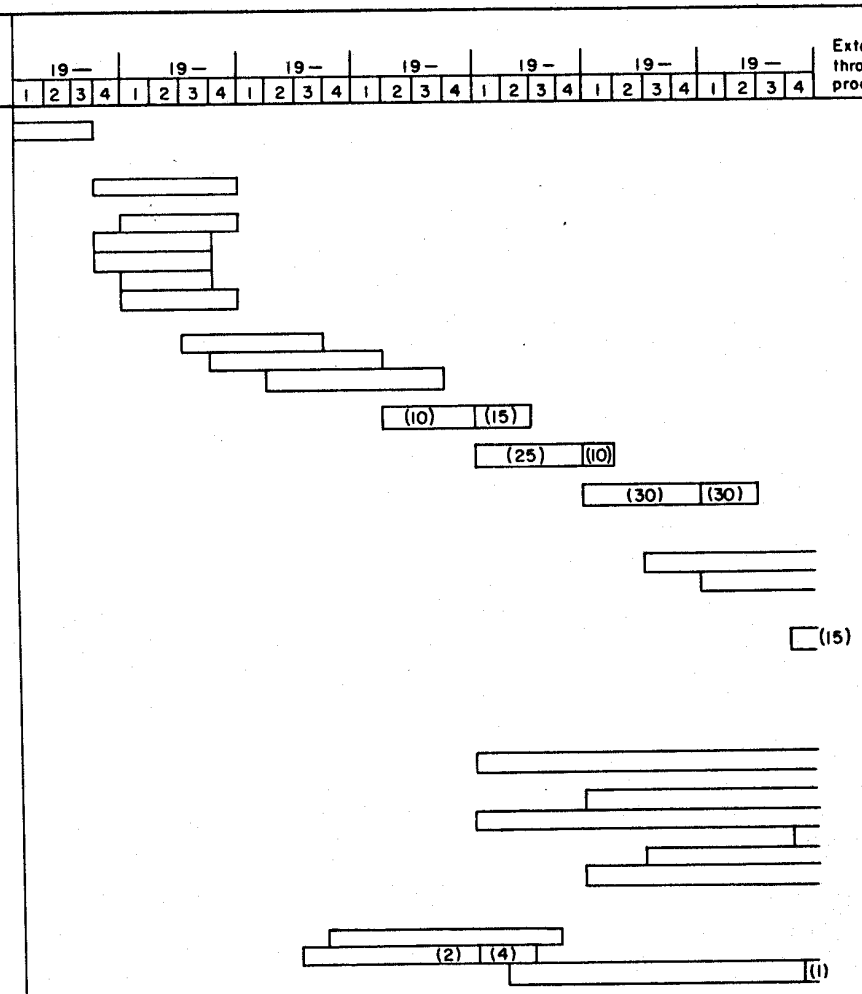


Table 4—Potential bottlenecks: state-of-the-art and resource shortages

(1) State-of-the-Art

Extent of Advancement Required

To - Develop

- Produce or Fabricate

Each Component of -

Prime Hardware (Such as: Airframe-Aerodynamic heating problem, materials structural integrity problem

Propulsion - Ceramic to metallic bonding problem

Guidance - Accelerometer accuracy problem

Support Equipment (Ex: Real time requirement in processing data

(2) Scarce Materials (Ex: Exotic Fuels)

- o Estimate of Quantity which Weapon System will require.
- o Total National Supply - Current
  - Anticipated

(3) Scarce Personnel Skills

Ex: Programmers, Astronauts, etc.

(4) Large Test Facility Requirements to Prove Feasibility

Ex: Wind Tunnel, Blow-down Facility

(5) Other

III. REQUIREMENTS FOR FINANCIAL DATA

In this section, two basic forms are furnished which lay out the major cost elements that should be estimated in determining the economic impact of future weapon systems.

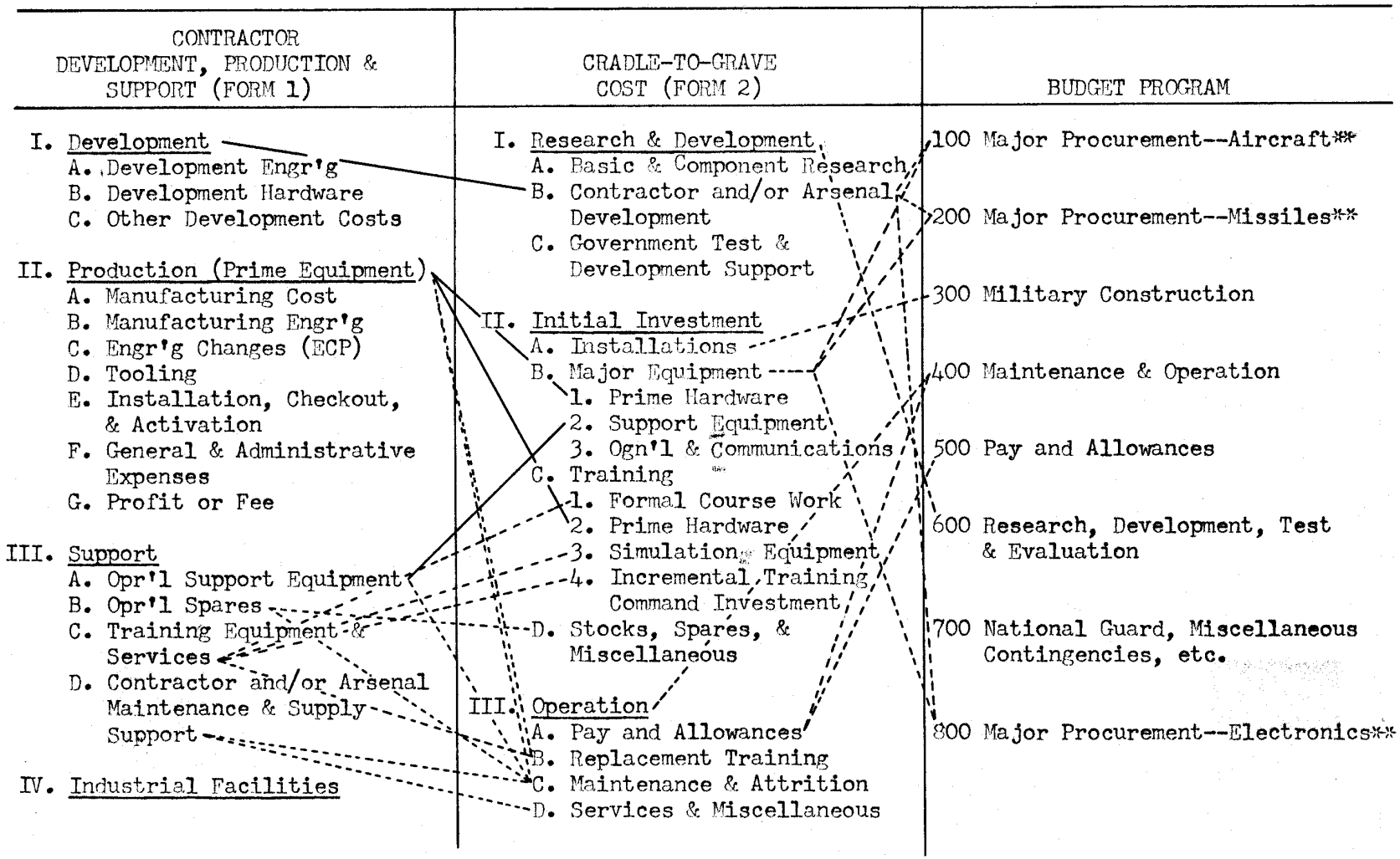
Form 1 lists those functions which a commercial contractor or government arsenal might perform if the system or systems suggested were to be developed and procured. Highly detailed statements of requirements are not necessary but each line item appropriate to the potential system should be evaluated and an estimate of the general financial magnitude furnished.

Form 2 presents a list of the typical major types of cost incurred in developing, procuring, and operating weapon systems. The list should be supplemented as required. For example, if the suggested system utilizes two or three distinct types of orbiting space hardware, these should be shown individually.

In Chart 7 which follows, the general relationship between the costs listed in Forms 1 and 2 is shown. The nature of the tie with major budget programs also is indicated. A more detailed cross-referencing with budget designations is provided on Form 2 itself.

The narrative material on the subsequent pages provides brief definitions of the cost elements listed on Forms 1 and 2.[4,13,16,17,21,24]

Chart 7 — Cross-identification of major cost elements*



*Illustrates major cross-references only.

**Including related ground support equipment.

DEFINITIONS

(FORM 1) CONTRACTOR AND/OR ARSENAL DEVELOPMENT, PRODUCTION, AND SUPPORT

I. Development - This element is to include all costs incurred by the contractor and/or arsenal to develop and test the weapon system. Complete systems used for testing are included - i.e., all costs up to production of hardware assigned to operational use plus certain continuing development work thereafter. It may help to visualize the coverage of this category as shown in Chart 8 which shreds the total both by cost element and development phase. The line items included in Form 1 condense this layout considerably.

A. Development Engineering - Limit this line item to labor-related expenses. Cost of fabrication of mockups etc. is covered in I.B. below.

1. Design

a. On Prime Equipment - This element is to be used to accumulate scientific and engineering services associated with research efforts, development, reliability work, and other areas except those which are either directly test associated or considered to be an essential part of production or manufacturing costs. It should include the direct labor charge for engineers, technicians, direct engineering support labor, as well as subcontracted engineering services (except for fabrication of mockups), plus fixed and variable burden, general and administrative expenses, and fee.

b. On Support Equipment - This element is to cover all engineering design costs associated with support equipment development. For example, it should include all ground-based support items (GSE) such as launchers, checkout consoles, handling equipment, etc., as well as ground-based data acquisition, processing, presentation, and communications equipment. It also should include the cost to engineer the various types of support equipment which may be required in orbit or on other planets.

2. Testing - This element includes engineering and engineering services costs associated with proving of the parts and components, subsystems and systems. It is to cover test engineering at all locations - in-plant, off-site, and government test locations. This too is a labor-related item; no fabrication costs or special test equipment are included.

Chart 8—Framework of contractor and/or arsenal development cost

SYSTEM

COMPONENT A

COMPONENT B

COMPONENT C

Phase of Development	ENGINEERING (Labor Including Burden)		HARDWARE (MATERIAL)									OTHER
			Manufacturing Cost									
	Engineers	Technicians & Engr'g Support	Material (Outside Purchases	Direct Production Labor	Burden or Overhead	Mfg. Engr'g	ECP	Installation, Checkout & Activation	G & A	Tooling	Fee	
Design												
Program Planning												
Preliminary Design												
Design												
Mockup & Prototype												
Testing												
Component Test												
System Test - Static (Simulated)												
System Test - Dynamic (Flight)												

a. In-Plant - Includes engineering-type costs associated with the development and reliability testing conducted within the manufacturing and laboratory facilities of the contractor and/or arsenal and other than that directly related to captive or dynamic (flight) testing.

b. Off-Site (Static and Flight - or Simulated and Live) - Includes costs associated with the static and flight test program. It is to be segregated approximately by site location of the testing i.e., Atlantic Missile Range, Pacific Missile Range, etc. System test engineering participation by component (subsystem) developers should be included here. For other than missile or space systems, this category should include the costs associated with simulated or live tests conducted at other than in-plant locations.

B. Development Hardware - This line item is to include both complete system hardware assigned to test and all of the mockups, components, parts, and development spares required.

1. Complete Prime Equipment Items - This element is to be used to accumulate all costs associated with complete systems assigned to test except instrumentation gear which is not an integral part of the operating weapon. It is to cover all costs of fabrication of the hardware including material, labor, burden, manufacturing engineering, engineering changes, tooling, general and administrative expenses, and fee.

2. Mockups and Components for Test - Use this element to cover the costs associated with special test articles, special modification to ground equipment for instrumentation, mockups, breadboard models, special devices, etc. It should also cover the cost of parts (bits and pieces) produced primarily for subcomponent testing or other associated development or research purposes. In addition, it should include development spares. Also general and administrative expenses and fee should be applied.

3. Instrumentation and Special Test Equipment - Include all material, direct labor, burden, general and administrative expense and fee associated with the creation, fabrication, installation, or removal of instrumentation and special test gear.

C. Other Development Costs

1. Fuels, Propellants, and Gases - Include estimated costs of those items which the contractor or arsenal would expect to furnish.

2. Data - Include all costs associated with reduction and analysis of development and test data plus the preparation of recurring and nonrecurring management, technical, and film reports.

Financial requirements Form 1:

Contractor and/or arsenal development, production, and support

Alternative Columnar Headings for:						
Strategic Offensive Systems[1]	Payload	Structure	Propulsion	Guidance & Control or Navigation	Other Sub-Systems	Total
Electronic Defense Systems	Data Acquisition	Data Processing	Data Presentation & Mgm't Control	Communications Incl. Land Lines	Other	Total
I. DEVELOPMENT						
A. Development Engineering (Hours and Dollars)						
Direct Labor						
Burden or Overhead						
1. Design						
a. On Prime Equipment						
b. On Support Equipment						
Earthbound						
In Space						
2. Testing						
a. In-Plant						
b. Off-Site (Simulated and Live)						
B. Development Hardware						
1. Complete Prime Equipment Items						
2. Mockups and Components for Test						
3. Instrumentation & Special Test Equipment						
C. Other Development Costs						
1. Fuels, Propellants, & Gases						
2. Data						
3. Manuals, QPRI and Other						
Total Contractor/Arsenal Development						
II. PRODUCTION (PRIME EQUIPMENT)						
No. of Units						
A. Manufacturing Cost						
1. Material and Other Outside Purchases						
2. Direct Labor						
3. Overhead or Burden						
B. Manufacturing Engineering						
C. Engineering Changes (ECP)						
D. Tooling						
E. Installation, Checkout & Activation						
F. General & Administrative Expenses						
G. Profit or Fee						
Total Production						
III. SUPPORT						
A. Operational Support Equipment (Quantity and Dollars)						
Sample Categories:						
1. Earthbound						
a. Launcher & Associated						
b. Checkout & Fire Control						
c. Ground Guidance (Radar and Computer)						
d. Maintenance & Logistics						
2. In Space						
a. Power Source						
b. Life Support						
c. Major Electronics						
B. Operational Spares						
C. Training Equipment & Services						
D. Contractor/Arsenal Maintenance & Supply Support						
Total Support						
IV. INDUSTRIAL FACILITIES						
GRAND TOTAL						

[1] Aircraft, Missile, Space, and certain Seaborne Systems.

3. Manuals, QPRI, and Other - Include all costs associated with the preparation of handbooks and manuals; effort towards furnishing qualitative information on personnel required to operate and maintain the system, subsystem, and support equipment; and any other contractor or arsenal costs in support of the development program.

II. Production (Prime Equipment) - This element is to cover all prime hardware to be placed in operational use - as opposed to that to be used for test purposes. Detail is to be provided in conventional cost categories as follows:

A. Manufacturing Cost - Include material (outside purchases), labor and burden; and cover through acceptance testing of the hardware.

1. Material or Outside Purchases - Include all applicable raw material i.e., items purchased in sheet, bar stock, casting or forging form, and described by metal specifications, weight, dimensional data etc.; purchased parts, i.e., componentry that can be procured off-the-shelf; and subcontracted items, i.e., parts built by an outside firm to a specific new design for incorporation in the product.

2. Direct Labor - Include an estimate of the hours and cost of work to be performed on fabrication, machining, assembly etc. Indicate the dollar/hour rates used in computing the cost. If the rates are assumed to change over time so indicate.

3. Overhead or Burden - Include all fixed burden items i.e., indirect costs that remain constant regardless of volume levels, such as depreciation, leasehold improvements, rent, property taxes, etc., and all variable burden i.e., indirect costs that change proportionately or gradually with fluctuation in production rate i.e., indirect labor, maintenance, power, factory supplies, telephone, transportation, etc. In selecting the burden rate assume normally efficient production methods and operation at expected per cent of capacity.

B. Manufacturing Engineering - This is normal engineering including all engineering services and miscellaneous material costs required to prepare for and monitor the actual fabrication or assembly line function. It is to be distinguished from development engineering.

C. Engineering Changes (ECP) - This is to be an estimate of the engineering and manufacturing cost of modifications of hardware design which are of a lesser nature than major model changes. In many cases, the maximum allowable factor is 10 to 20 per cent of manufacturing costs.

D. Tooling - This item is to include costs of jigs, dies, fixtures, production test equipment, etc., originating as a result of the requirement to manufacture the prime hardware. It is to cover both

the cost of the new tooling required and the cost of repair and maintenance of tooling.

E. Installation, Checkout, and Activation - This item applies to ground equipment. Include all costs associated with integration, installation, checkout, and activation of sites, such as overall planning, construction surveillance, installation, testing and checkout of equipment, and other related activities and services prior to operational acceptance.

F. General and Administrative Expense - Include a factor covering operating costs of corporate or other top staff agencies, plus the other limited company-wide expenditures normally falling in this category.

G. Profit or Fee - Applies only to contractor organizations. Include at an average flat rate, for example, 7 per cent.

III. Support - This item is to include all support equipment assigned to operational use, spares for both operational prime and support equipment, training equipment and services, and contractor and/or arsenal depot support.

A. Operational Support Equipment - Figures are to include all costs to produce and install the operational support hardware - i.e., material, direct labor, burden, manufacturing engineering, engineering changes, tooling, installation, activation and checkout, general and administrative expenses, and fee. An approximate breakout by major type of equipment should be furnished as appropriate.

B. Operational Spares - Include spare parts (bits and pieces) required for pipeline and consumption on both prime and support equipment. Conceptually, spare complete end items of equipment are to be shown under II.--Production (Prime Equipment) and spare parts manufactured to special specifications or for test are to be included under development costs.

C. Training Equipment and Services - This category should include all costs which are associated primarily with the training program. It should cover equipment requirements and contractor or arsenal manpower necessary for initial training of individual direct operating personnel, training of the squadron or battalion as an integrated on-site operating unit, and maintaining the proficiency of the unit. This will include design and construction of trainers, standard parts for instruction purposes, training course preparation, salaries of instructors, etc.

D. Contractor and/or Arsenal Maintenance and Supply Support (Depot-Type) - Include costs to cover repairs, time-phased inspection, modification, and all other depot-type maintenance to be performed by the contractor or arsenal. Also, include costs to be incurred in handling weapon system supply items. This may include such

functions as receiving, storage, inventory and associated locator record-keeping, packing and crating, issue, and shipping.

IV. Industrial Facilities - Include an estimate of the cost of contractor or arsenal facilities assuming all new construction and major production equipment is required. Attach a brief description of the extent of this layout. Also comment on the likelihood of inheritance of all or part of these facilities and equipment.

(FORM 2) CRADLE-TO-GRAVE COST

Data on all line items of Form 2 which are preceded by asterisks(*) can be taken from the appropriate portions of Form 1. In the case of line items preceded by a plus (+) sign, the category includes cost elements from Form 1 but is not limited exclusively to contractor and/or arsenal-associated costs.

Also note the reference column at the left on Form 2. This provides the approximate types of funds used for these line items assuming current funding designations.

Numbered columns at the right provide space for pricing the series of cases necessary in order to determine the cost sensitivity of alternate hardware designs, development programs, or operational concepts.

I. Research and Development - This category is to include all costs required to bring a weapon system to the point where it may be procured for operational use. In most cases, it is convenient to divide this requirement into three major parts, namely, basic and component research, system development by a contractor or arsenal team, and test support at a military or other governmental agency test facility.

A. Basic and Component Research - This element covers theoretical and conceptual work in each physical and social science field necessary in order to make early feasibility determinations on the system proposal. It also covers efforts to develop new or improved major components prior to official establishment of the program on a weapon system basis.

B. Contractor and/or Arsenal Development - Include the costs of those functions which, under the weapon system management concept, a contractor(s) or arsenal might be expected to handle. These costs are shown as the total of Item I - Development in Form 1. For a more detailed statement of content refer to the definitions of the line items under that category.

C. Government Test and Development Support - Include the costs of the functions which are carried on by government test centers in support of development programs. The primary objective of these centers is obtaining data on test results. Their function is built around creation of the necessary environment in which to conduct the test.

Financial requirements Form 2:
Cradle-to-grave-cost

Current Budget Fund Designation			Sensitivity Analysis: Basic Case	Variable ____ Case 2	Variable ____ Case 3	Variable ____ Case 4	Variable ____ Case 5	Variable ____ Case 6	Variable ____ Case 7	Extend as Required
		I. RESEARCH & DEVELOPMENT								
600		A. Basic & Component Research								
1,2 & 800	*	B. Contractor and/or Arsenal Development								
600		C. Government Test & Development Support								
		TOTAL R & D								
		II. INITIAL INVESTMENT								
300		A. Installations								
		1. Launch Areas								
		a. Launch Pads or Pits								
		b. Propellant Storage, Transfer & Decontamination								
		c. Blockhouse, Utilities, & Tunneling								
		2. Tracking Facilities								
		3. Support Area								
		a. Personnel Facilities								
		b. Operations, Maintenance, Storage, & Utilities								
1,2 & 800		B. Major Equipment								
	*	1. Prime Hardware								
		a. Payload								
		b. Structure								
		c. Guidance & Control								
		d. Propulsion								
		e. Other								
	*	2. Support Equipment (Suggested Categories:)								
		a. Earthbound								
		1. Launcher & Associated								
		2. Checkout & Fire Control								
		3. Data Acquisition & Analysis								
		4. Maintenance & Logistics								
		b. In Space								
		1. Power Source								
		2. Life Support								
		3. Major Electronics								
		3. Organizational Equipment (Incl. Comm.)								
		C. Training								
4 & 500	+	1. Formal Course Work								
1,2 & 800	*	2. Prime Hardware								
1,2 & 800	*	3. Simulation Equipment (At Opn'l Site)								
1,2,3 & 800	+	4. Incremental Training Command Investment								
1,2,4 & 800		D. Stocks, Spares, and Miscellaneous								
		TOTAL INVESTMENT								
		III. OPERATION								
500		A. Pay & Allowances								
		B. Replacement Training								
4 & 500		1. Personnel								
1,2 & 800	*	2. Prime Hardware								
		C. Maintenance & Attrition								
1,2,4,5 & 800		1. Maintenance								
		a. Installations								
	+	b. Prime Hardware								
	+	c. Support Equipment								
	+	d. Training & Orgn'l Equipment								
1,2 & 800		2. Attrition								
	+	a. Prime Hardware								
	+	b. Support Equipment								
	+	c. Training & Orgn'l Equipment								
400	+	D. Services and Miscellaneous								
		TOTAL OPERATION								
		TOTAL CRADLE-TO-GRAVE COST								

*Entirely from Form 1.
+Partially from Form 1.

Emphasis is placed on acquisition of various types of electronic and photographic test data. It also covers processing and analysis of this data. Include both the investment required for test equipment and facilities and the operational cost of conducting and supporting the test through to presentation of results.

II. Initial Investment - This category covers the cost of introducing the new weapon system into the operational force and of building this weapon to peak force strength. It includes not only the procurement of prime equipment but also all of the other elements of the system necessary in order to provide it with full combat capability, i.e., support equipment, facilities, initial training of personnel, stocks and spares, etc.

A. Installations - This element is to cover all nonseverable construction required to place a weapon system in the field after research and development is complete. In other words, test facilities are not to be included. Appropriate segregation of major elements of installations vary considerably depending upon the type of mission for which the weapon is designed. A breakout is shown which is useful for missile and space systems. For aircraft, perhaps a split between personnel-associated and equipment-associated facilities (similar to that shown for support area construction on missile systems) is appropriate. Under aircraft equipment facilities a breakout into airfield; fuel storage and dispensing; communication, navaids, and airfield lighting; facilities for operations, maintenance, training, storage, and shops can be used. For personnel facilities, division can be made into troop housing, family housing, administrative and community buildings, utilities, and medical facilities. Ground electronic systems require construction to house, and in many cases, harden, the often quite widely dispersed equipments shown in a layout of the system (Table 2 above). They, of course, also require the conventional types of personnel and administration, maintenance and supply buildings.

B. Major Equipment - This element covers post-R&D requirements for the major procurement funds necessary to purchase initial UE equipment including an out-of-commission allowance in the case of aircraft systems. It does not include equipment to be used in training or to replace attritted hardware. Neither does it cover the spare parts necessary for maintenance. The subelements suggested again apply most closely to missile and space weapons and therefore, should be adapted with minimum changes as appropriate for aircraft, seaborne, or electronic systems.

1. Prime Hardware - Excerpt the required figures from the columns of Item II Production (Prime Equipment) on Form 1 deducting the cost of non-UE prime hardware.

2. Support Equipment - Excerpt required figures from Item IIIA-Operational Support Equipment on Form 1. Again deduct the cost of non-UE equipment.

3. Organizational Equipment (Incl. Communications)- Include the cost of conventional equipment for support units, for example, motor vehicles, materials handling, construction, maintenance, food service, medical, etc. Also, include the cost of basic conventional communication equipment - i.e., telephone, teletype, etc.

C. Training - Include all costs necessary to provide personnel with the initial capability required at the time of phase-in of the operational units. Do not include charges for maintaining proficiency or training of replacements because these are considered to be operating charges rather than investment costs.

1. Formal Course Work - Include the costs of formal training (not OJT) by a training command. Conceptually this should cover pay and allowances of students while taking the course, salaries of faculty, a pro rata share of the overhead of the training command including minor training aids, maintenance on training equipment assigned to the training unit, etc.

2. Prime Hardware - Covers all prime hardware to be expended for the purpose of training initial crews. Excerpt the appropriate portions of the costs shown in Item II-Production (Prime Equipment) on Form 1. This element applies primarily to missile and space systems where the hardware is destroyed in the process of training. In cases where the hardware is retained for example in aircraft and electronic systems, the cost should be shown under Item II C 4, Incremental Training Command Investment, below.

3. Simulation Equipment (At Operational Site) - Include the cost of equipment which will simulate the operational sequence for proficiency training purposes. Also, if the proposed training concept stipulates that replacements will be trained on site, include the cost of training equipment required for this purpose. This cost is shown as a portion of Item III C - Training Equipment and Services on Form 1.

4. Incremental Training Command Investment - Include both the new facilities and equipment required by the training command in order to present the formal courses necessary. This construction and equipment would be located physically at the training base or bases.

D. Stocks, Spares, and Miscellaneous - Conceptually this item should include such costs as the initial stocks of conventional supplies; spares and spare parts required in warehouses and logistics pipelines; transportation to the operational site of initial equipment, supplies, personnel including their dependents and household goods; initial operational fuel, propellant, and gas requirements, etc.

III. Operation - This category covers the cost of maintaining the capability of the weapon system in the field after all costs of initial phase-in have been incurred. Because total cradle-to-grave cost is sensitive to the number of years of deployment and since it is uncertain how long a weapon will remain in operation, it is suggested that financial requirements be shown for several periods, for example, 3, 5, and 7 years.

A. Pay and Allowances - Include the salaries or wages and the cash allowances to all military and civilian operational, maintenance and other support personnel, located at operational bases. Do not include possible contractor and/or development arsenal people, however.

B. Replacement and Proficiency Training

1. Personnel - Include the cost of formal course work necessary to train new personnel to replace those who are transferred.

2. Prime Hardware - Excerpt the appropriate portion from Item II-Production (Prime Equipment) on Form 1.

C. Maintenance and Attrition

1. Maintenance - Include the charges other than pay of personnel to keep operational facilities and the various types of required equipment in repair.

a. Installations - Cover the cost of material and contractual services necessary to maintain the facilities.

b. Prime Hardware - Cover the cost of spare parts and other materials for organizational and field maintenance at the base level plus all costs including labor for depot-type repairs. Spare parts cost is included in Item III B-Operational Spares on Form 1.

c. Support Equipment - Same definition as for maintenance of Prime Hardware above.

d. Training and Organizational Equipment - Same definition as for maintenance of Prime Hardware above.

2. Attrition - Include an estimate of the cost of replacing complete equipment items which are destroyed or otherwise made permanently inoperable by accident, wear-out, etc.

a. Prime Hardware - Excerpt the appropriate portion from II-Production (Prime Equipment) on Form 1.

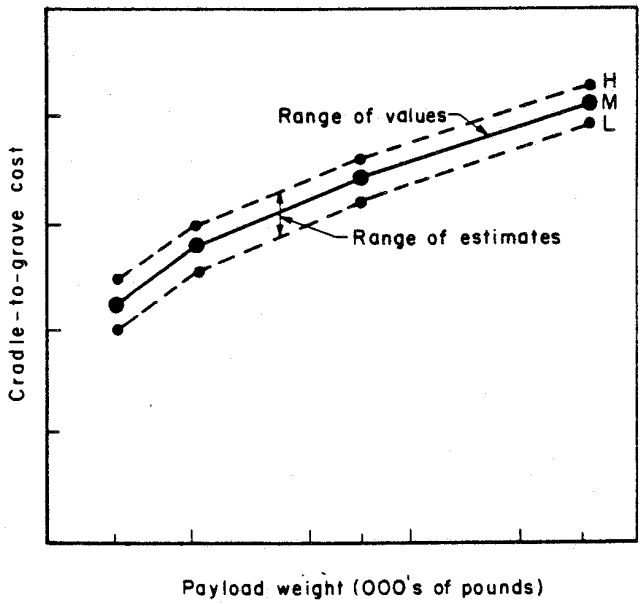
b. Support Equipment - Excerpt the appropriate portion from Item III A, Operational Support Equipment on Form 1.

c. Training and Organizational Equipment - For the cost of replacement of training equipment, excerpt the appropriate portion of Item III C, Training Equipment and Services.

D. Services and Miscellaneous - This item should include the cost of transporting replacement equipment and personnel, and supplies consumed; fuels, propellants, and gases; material and contractual service charges i.e., excluding pay of personnel--for administration, flight service, supply operations, medical and food services, etc. In the case of ground electronic systems, show rental of leased lines and power costs separately when they are sizeable.

IV. Example of Sensitivity Analysis

In Section I, the importance of accumulating financial data which will allow analysis of sensitivity of cost to change in development program, hardware design, or operational concept is stressed. Ranges of values which bracket the cost implications of alternative system characteristics and ranges of estimates which indicate the impact of alternative estimates of cost for a given physical requirement are suggested. Form 2 just discussed, lays out the major elements which should be costed in order to obtain plot points for these ranges of values and estimates. The following chart (Chart 9) shows a sample format for presenting the resulting parametric relationship together with the primary financial back-up data needed to explain this relationship.



Payload Weight	1000			2000			5000			9000		
Case No.	1			2			3			4		
Low, Med., or High Est.	L	M	H	L	M	H	L	M	H	L	M	H
R & D												
Initial Investment Installations Major Equipment Prime Hardware Support & Org'nl Eqpt. Training Stocks, Spares, & Mis.												
Operation (5 Yrs) Pay & Allowances Replacement Training Maintenance & Attr. Services & Mis.												
TOTAL												

Chart 9—Sensitivity to variation of a single characteristic*

* All other assumptions concerning the weapon system design, development, or operation remain constant.

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